NEUTRINO DATA AND NEUTRINO-ANTINEUTRINO TRANSITION

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Abstract

A problem, whether a neutrino-antineutrino transition could be responsible for the muon neutrino deficit found in underground experiments (Super-Kamiokande, MACRO, Soudan 2) and in the accelerator long-baseline K2K experiment, is discussed in this paper. The intention of the work is not consideration of concrete models for muon neutrino -antineutrino transition but a desire to attract an attention to another possibility of understanding the nature of the measured muon neutrino deficit in neutrino experiments.

1 Introduction

The deficit of up going muon neutrinos in comparison with the expected ones was found in different underground experiments [1, 2, 3]. In more detail and for wide range of energy this effect was registed at the Super-Kamiokande detector [1]. Some later the effect of the muon neutrino disapearance was cofirmed in the accelerator long-baseline K2K experiment [4]. Results of these experiments were interpreted as the existence of muon neutrino-tau neutrino oscillations. The corresponding values of oscillation parameters were calculated.

It is necessary to note that the discussed experiments are experiments on the disapperance of initial neutrinos, in which were not reliably defined types of newborn neutrinos.

2 Neutrino-antineutrino transition

Another possibility can be considered in order to explain the observed muon neutrino deficit. Let us assume that muon neutrinos transit (not oscillate!) to muon antineutrinos. As a cross section of muon antineutrino-nucleon interaction is less than muon neutrino-nucleon one (about 2 times at energy of about 1GeV), a number of neutrino events detected will be less than the expected one. We can estimate the ratio value (R) of the number of muons (produced by atmospheric neutrinos deep underground) arised in the case of realizing the muon neutrino-muon antineutrino transition to that with no transition.

Fluxes of atmospheric neutrinos coming to the sea level at different directions for a wide energy range were calculated in [5]. In [6] calculations were made to study the main features of fluxes of atmospheric muon neutrinos responsible for a prodution of unerground muons at, in particular, middle and effective energies of neutrinos responsible for these muons, neutrinos to antineutrinos ratio. Our estimations are based on these calculations.

The ratio value (R) estimated under conditions that all up going muon neutrino transit to muon antineutrino are equal to as follows

$$0.625 \quad \text{for } E_{\nu_\mu} > 0.3 \text{ GeV} \tag{1}$$

$$0.585 \quad \text{for } E_{\nu_\mu} > 10 \text{ GeV} \tag{2}$$

As it is seen from these values, the ratio R is aproximately the same paramerter for wide energy range.

The R-estimations obtained can be compared with the experimental data from Super-Kamiokande published in [1]. There is the double ratio of events experimentally measured to ones calculated with the Monte Carlo method in this work

$$R = \left(\frac{\mu}{e}\right)_{DATA} / \left(\frac{\mu}{e}\right)_{MC} \tag{3}$$

where (μ/e) — μ-like to e-like events ratio

For two energy ranges of $E < 1.33$ GeV and $E > 1.33$ GeV R - values are the following

$$R_{sub-GeV} = 0.658 \pm 0.016 \pm 0.055 \tag{4}$$

$$R_{multi-GeV+PC} = 0.702^{+0.032}_{-0.030} \pm 0.101 \tag{5}$$

As the number of experimentally measured e-like events in Super Kamiokande coincides with the expected one, it is possible to assume with reasonable accuracy that

$$R = \left(\frac{\mu}{e}\right)_{DATA} / \left(\frac{\mu}{e}\right)_{M} \approx \mu_{DATA}/\mu_{MK} \tag{6}$$

Comparing the estimation values (1) and (2) with the experimentally measured values (4) and (5) from Super Kamiokande, one can arrive to a conclusion that the hypothesis of muon neutrino-muon antineutrino transition is in a good agreement with the experimental data within the shown errors.

3 Conclusion

The alternative variant of an explanation of the observed muon neutrino deficit is suggested in this paper. Namely, the possible transition of muon neutrinos to muon antineutrinos during muon neutrino path through the Earth was used to obtain the estimation values for comparing with the experimental Super Kamiokande data. The result was found to be positive within experimental errors. This means that the hypothesis of muon neutrino-muon antineutrino transitions can not be ruled out and it would be very desirable to test it.

Both the current experiments and the future ones are very expensive, it seems very important to foresee the possibility of verifications of above mentioned hypothesis in these experiments. For instance, it would be most importantly to install a magnetic

spectrometer for charge mesurments of neutrino-produced muons in the current K2K experiment in the place of the Super Kamiokande disposition. The presence of positively charged muons in a magnetic spectrometer would be the direct corroboration of muon neutrino transitions to muon antineutrinos.

References

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